

WHY ARE AMPHIBIAN HELMINTH COMMUNITIES DEPAUPERATE?

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Abstract

Barton, D.P., 1997. Why are amphibian helminth communities depauperate? *Memoirs of the Museum of Victoria* 56(2): 581-586.

The helminth community structure of the introduced toad, *Bufo marinus*, and the native frog, *Litoria inermis*, are compared, for the first time. Previous studies have found the helminth communities of amphibians to be depauperate although no study has previously detailed a community from a tropical host species. Both *B. marinus* and *L. inermis* were infected with a higher number of helminth species than the previously recorded anuran average, but contained fewer individuals. The use of the core and satellite species concept in these depauperate communities is considered incorrect due to the isolationist characteristic of the communities.

Introduction

The community ecology of helminths is emerging as an informative field of research, although amphibians have received little attention from parasite ecologists (Lluch et al., 1987; Aho, 1990; Esch et al., 1990). The majority of work on helminths of these hosts has concentrated on faunistic surveys or discussions on phylogenetic relationships between host and parasite (see Aho, 1990; Muzzall, 1991b). Studies of the helminth fauna of amphibians at the infracommunity level are, however, practically non-existent (Aho, 1990), despite the fact that this level of study comprises the basic data collected in any parasitological survey (Holmes and Price, 1986).

The helminth communities of amphibians have been found by various workers to be depauperate (low in species richness) and isolationist in character. Examples of this type of community have been reported for salamanders (Goater et al., 1987; Aho, 1990; Muzzall, 1990, 1991a) and frogs (Muzzall, 1991b). However, comparatively rich helminth faunas have been reported from ranid frogs in Poland (Kuc and Sulgostowska, 1988a, 1988b). From his review of amphibian parasite literature, Aho (1990) found that anurans had an average richness of 0.98 helminth species per host individual, while salamanders were slightly lower with an average of 0.7.

The community ecology of helminths within amphibians in Australia has never been documented especially for the introduced toad, *Bufo marinus*. This paper aims to describe the dynamics of the helminth communities within

the introduced toad compared to a native amphibian, *Litoria inermis*.

Materials and methods

Bufo marinus and *Litoria inermis* were collected from 'Bentley', a privately owned property at the 'Bentley Estate', approximately 30 km south of Townsville in April 1991. Animals were kept overnight and dissected the following day; dissection followed a fatal dose (2-5 drops, dependent on size) of 'Lethabarb' (Euthanasia injection Pentobarbitone solution) sprinkled onto the dorsal surface. A ventral incision was made from the pelvic to the pectoral girdle exposing the body cavity. The following organs were removed and placed in separate dishes containing a 0.8% sodium chloride solution for inspection: lungs, stomach, intestine and rectum, urinary bladder, kidney, liver and gall bladder. Occasionally, the mouth cavity, nostrils, heart, and leg musculature were also examined. Organs were examined under a stereo microscope using transmitted light.

Helminths were removed from dissected organs with the aid of fine dissecting forceps; numbers and location within host for each type of helminth were recorded.

Definitions of ecological terms follow Margolis et al. (1982). Prevalence of infection is the percentage of hosts infected in a sample. Mean intensity of infection is the average number of helminth individuals per infected host. Total helminth intensity is the total number of helminth individuals of all helminth species per host individual. Species richness is the number of helminth species per host.

Analyses of helminth community structure were carried out at the infracommunity (host individual) and component community (host species) level. Measures of infracommunity structure used were: mean number of helminth individuals per host individual, mean number of helminth species per host, and mean Brillouin's index per host (infected hosts only). Measures of component community structure (taken from grouped data) were: total number of helminth species, number of component species, Simpson's index, and Shannon-Weiner index. Analyses of community structure follow methods as outlined by Magurran (1988). Values for indices were calculated for each infracommunity and included all helminths, irrespective of site of infection, using natural logarithms (\log_e). The final statistic is expressed as a mean (\bar{x}) \pm SE \bar{x} .

Analysis of the similarity of the helminth communities of *B. marinus* and *L. inermis* was completed with a Jaccard similarity index following the methods outlined by Magurran (1988). Comparison of the helminth community structure between *B. marinus* and *L. inermis* was done by a two sample t-test.

Helminth species are determined as core species if their prevalence of infection is over 70%, secondary species if 40–70%, or satellite species if less than 40% (Stock and Holmes, 1987). A component species is defined as having a prevalence of at least 10% (Bush et al., 1990).

Results

A total of 33 *B. marinus* and 53 *L. inermis* were collected from Bentley in April 1991. Twelve helminth species were collected from *B. marinus* and *L. inermis*: 5 digeneans (*Mesocoelium* sp., *Dolichosaccus symmetrus*, *D. juvenilis*, *D. helocirrus*, *Pleurogenoides* sp.), 5 nematodes (*Rhabdias* sp., *Maxvachonia* sp., *Johnpearsonia pearsoni*, *Cosmocerca* sp.1, Nematode larvae) and 2 cestodes (*Nematotaenia hylae*, *Diphyllobothrium* sp. larvae) (Table 1). *Bufo marinus* was infected with 9 helminth species and *L. inermis* with 8 species; 5 of these helminth species were shared (see Table 1). The Jaccard similarity index of the helminth communities of *B. marinus* and *L. inermis* was 0.417. *Rhabdias* sp. was the most commonly encountered helminth for both host species.

Of the 33 toads collected, 28 (84.8%) were infected with at least one helminth; 47 (88.7%) of 53 *L. inermis* were infected with at least one helminth (Figure 1). Table 2 presents general

infection parameters for both *B. marinus* and *L. inermis* compared to values calculated by Aho (1990) for anurans. Both *B. marinus* and *L. inermis* were infected with more helminth species than has been recorded as the anuran average; intensity of infection was below the anuran average.

The diversity characteristics of the infracommunities of *B. marinus* and *L. inermis* are presented in Table 3. *Bufo marinus* was infected with a significantly higher mean number of helminths ($t_{31}=2.57$, $p=0.015$), mean number of helminth species ($t_{44.8}=2.65$, $p=0.011$) and mean Brillouin's index ($t_{39.9}=3.01$, $p=0.005$).

The diversity characteristics of the component communities of *B. marinus* and *L. inermis* are presented in Table 4. Only 4 helminth species for *B. marinus*, and 2 for *L. inermis*, were considered component species (prevalence >10%; see Table 1). *Rhabdias* sp. was the only component species infecting both host species. *Bufo marinus* had higher values for the Simpson's Index and the Shannon-Weiner Index.

Discussion

The helminth communities of *B. marinus* and *L. inermis* have been documented for the first time. Despite the limited geographical and seasonal nature of the study, some important data are revealed.

In general, the characteristics of the helminth fauna of *B. marinus* and *L. inermis* correspond to those outlined by Aho (1990) for anurans. The helminth community is depauperate and isolationist in character. The community is considered isolationist due to the low number of helminth species and individuals present (see Sousa, 1994).

Average species richness for both *B. marinus* and *L. inermis* was higher than the average of 0.98 calculated by Aho (1990) for anurans in general (see Table 2). Average helminth intensity for both species, however, was below the anuran average. The studies reviewed by Aho (1990) were primarily based in temperate climates (North America and Europe) and the results found in this study may be due to its tropical location. This relationship, however, requires further work detailing the communities within various tropical amphibian species to determine its accuracy.

Bufo marinus was found to have a significantly more diverse helminth community than *L. inermis*. Higher values for all parameters were

Table 1. Helminth infracommunities of 33 *Bufo marinus* and 53 *Litoria inermis* collected from Bentley in April 1991.

Helminth Species	Site	<i>Bufo marinus</i>				<i>Litoria inermis</i>			
		No. Infected (%)	Mean Intensity	SE \bar{x}	Maximum Infection	No. Infected (%)	Mean Intensity	SE \bar{x}	Maximum Infection
<i>Mesocoelium</i> sp.	Intestine	9 (27.3)	5.1	1.3	12	2 (3.8)	1.0	0.0	1
<i>Dolichosaccus symmetricus</i>	Intestine	1 (3.0)	2.0	0.0	2	1 (3.0)	1.0	0.0	1
<i>Dolichosaccus juvenilis</i>	Intestine	1 (3.0)	10.0	0.0	10				
<i>Dolichosaccus helocirrus</i>	Intestine	4 (12.1)	4.5	1.2	8				
<i>Pleurogenoides</i> sp.	Intestine	3 (9.1)	6.3	2.3	10	4 (7.5)	8.5	4.7	22
<i>Rhabdias</i> sp.	Lung	25 (75.8)	6.3	2.1	49	44 (83.0)	2.0	0.3	10
<i>Maxvachonia</i> sp.	Intestine	6 (18.2)	2.5	1.1	8	1 (1.9)	2.0	0.0	2
<i>Johnpearsonia pearsoni</i>	Intestine	3 (9.1)	1.0	0.0	1				
<i>Cosmocerca</i> sp. 1	Rectum	1 (3.0)	1.0	0.0	1				
Nematode larvae	Mesenteries					1 (1.9)	1.0	0.0	1
<i>Nematotenia hylae</i>	Intestine					1 (1.9)	1.0	0.0	1
<i>Diphyllolothrium</i> sp. (larva)	Leg muscles					6 (11.3)	3.3	0.8	7

Table 2. Helminth intensity and species richness within communities from *Bufo marinus* and *Litoria inermis* compared to values for anurans as calculated by Aho (1990).

		Helminth Intensity	Species Richness
<i>Bufo marinus</i> (This study)	Mean Intensity (SE \bar{x})	8.18 (2.12)	1.57 (0.19)
	Range of Infection	0–52	0–5
<i>Litoria inermis</i> (This study)	Mean Intensity (SE \bar{x})	2.89 (0.59)	1.15 (0.11)
	Range of Infection	0–25	0–4
Anurans (Aho, 1990)	Mean Intensity (SE \bar{x})	11.55 (1.86)	0.98 (0.07)
	Range of Infection	0–45	0–9

Table 3. Diversity characteristics of the infracommunities of helminths of *Bufo marinus* and *Litoria inermis* (infected hosts only) collected from Bentley in April 1991.

Characteristic	<i>Bufo marinus</i>	<i>Litoria inermis</i>
Number of infected hosts	28	47
Mean number of helminth individuals (SE \bar{x})	9.64 (2.40)	3.26 (0.65)
Mean number of helminth species (SE \bar{x})	1.86 (0.18)	1.30 (0.11)
Mean Brillouin's index (SE \bar{x})	0.30 (0.06)	0.09 (0.03)
Mean evenness (SE \bar{x})	0.48 (0.09)	0.16 (0.05)

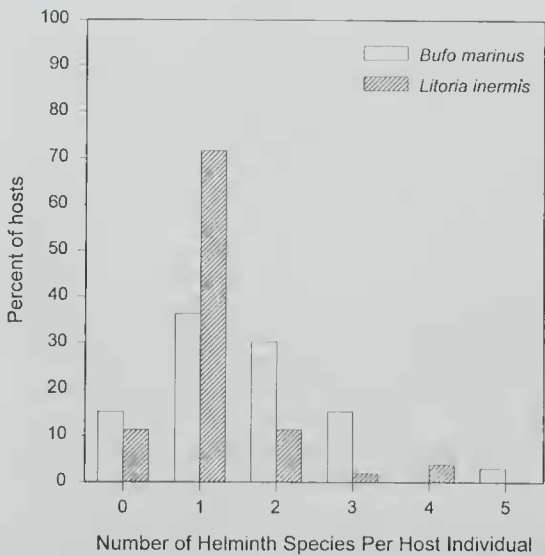


Figure 1. Distribution of number of helminth species per host individual for *Bufo marinus* and *Litoria inermis* collected from Bentley.

Table 4. Diversity characteristics of the component communities of helminths of infected *Bufo marinus* and *Litoria inermis* collected from Bentley in April 1991.

Characteristic	<i>Bufo marinus</i>	<i>Litoria inermis</i>
Number of helminth species	9	8
Number of component species	4	2
Simpson's index	2.65	2.50
Shannon-Weiner index	1.37	0.98

recorded for *B. marinus* at both the infracommunity and component community levels. Although helminth species were shared between the host species, level of similarity was below 0.5. In addition, infection levels were generally higher in *B. marinus*. These results are of interest considering that *B. marinus* is an introduced

host to Australia that has acquired the majority of its helminths from Australian native frogs and reptiles (Barton, 1995). The toad, therefore, would appear to have successfully adapted to the Australian parasite fauna, and them to it. The helminths of these native hosts, therefore, would appear not to be highly host-specific.

Possible reasons for *B. marinus* having the more diverse helminth community include host size, diet, habit and habitat differences.

The average host size of *L. inermis* is considerably smaller than that of *B. marinus* (pers. obs.). Further studies of native amphibians of sizes closer to the toad (for example, *Cyclorana* species) need to be undertaken to determine the true extent of the relationship of host size to helminth community dynamics.

Bufo marinus is a wide foraging predator (Strüssmann et al., 1984) whereas *L. inermis* is an ambush predator (pers. obs.). The diet of the two host species at Bentley differed in the size (small for *L. inermis* and large for *B. marinus*) and the variety (small flying insects for *L. inermis* and large beetles, ants, large flying insects for *B. marinus*) of prey taken. Ambush predators, theoretically, have a less diverse helminth fauna due to the lower variety of prey encountered (Aho, 1990). Of the eight helminth species collected from *L. inermis* in April 1991, six are reliant on dietary transmission (see Prudhoe and Bray, 1982). The helminth fauna of *B. marinus*, however, has only five of the nine species reliant on dietary transmission.

The majority of the nematodes in this study have direct life cycles (see Anderson, 1992) either through skin penetration (for example *Rhabdias* sp.) or consumption of infective larvae. Kennedy et al. (1986) and Aho (1990) suggested that nematodes with direct life cycles would play a major role in the species richness of isolationist helminth communities, as were found here.

The concept of core and satellite parasite species was proposed by Hanski (1982) and has since been adapted to parasite communities. Core species are generally single host species specialists, adapted to each other and widespread and abundant within that host species. Satellite species are acquired by exchange from the ecological associates of the host and are sporadic and less abundant. Within an intra-community, it is the core species that will interact, usually in a negative association, whereas secondary species are isolated from other species (Sousa, 1994). In exchange, one host's core species becomes another's satellite species

(Freeland, 1983; Holmes and Price, 1986). Aho (1990) suggested, however, that due to the isolationist characteristic of amphibian parasite communities, that species be considered either common (prevalence over 50%) or rare (below 50%).

The concept of core and satellite species works well in highly diverse and species rich helminth communities, such as those found in aquatic birds (see Stock and Holmes, 1987). In species-poor communities, such as those found in amphibians, however, such terms are inadequate. Helminth communities of amphibians are generally made up of host generalists which freely exchange between host species. This makes the community, by definition (see Bush and Holmes, 1986), satellite. For such species-poor communities even the classification of species as common or rare (see Aho, 1990) does not detail the community sufficiently. Listing the component species (prevalence greater than 10%; Bush et al., 1990) would give a better idea of the diversity of the community.

The study of the community ecology of helminths of amphibians is an informative field. This field is in its infancy, however, and requires more work to be carried out on communities within tropical amphibians. It is hoped that this study will provide the starting step for future ecological studies of amphibian species in Australia.

Acknowledgments

I would like to thank the organisers of the Invertebrate Biodiversity and Conservation conference for requesting this paper. In addition, I am grateful to Mr Eddie Hurley for the use of his property for the collection of animals and Dr Mark Hearnden for his statistical advice. I was supported by an Australian Postgraduate Research Award throughout this study.

References

- Aho, J.M., 1990. Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. Pp. 157-195 in: Esch, G.W., Bush, A.O. and Aho, J.M. (eds), *Parasite communities: patterns and processes*. Chapman and Hall: London.
- Anderson, R.C., 1992. *Nematode parasites of vertebrates: their development and transmission*. C.A.B.: Oxon.
- Barton, D.P., 1995. *The cane toad: a new host for helminth parasites in Australia*. PhD Thesis, James Cook University of North Queensland, Australia.

- Bush, A.O. and Holmes, J.C., 1986. Intestinal helminths of lesser scaup ducks: patterns of association. *Canadian Journal of Zoology* 64: 132-141.
- Bush, A.O., Aho, J.M. and Kennedy, C.R., 1990. Ecological versus phylogenetic determinants of helminth parasite community. *Evolutionary Ecology* 4: 1-20.
- Esch, G.W., Shostak, A.W., Marcogliese, D.J. and Goater, T.M., 1990. Patterns and processes in helminth parasite communities: An overview. Pp. 1-19 in: Esch, G.W., Bush, A.O. and Aho, J.M. (eds), *Parasite communities: patterns and processes*. Chapman and Hall: London.
- Freeland, W.J., 1983. Parasites and the coexistence of animal host species. *American Naturalist* 121: 223-236.
- Goater, T.M., Esch, G.W. and Bush, A.O., 1987. Helminth parasites of sympatric salamanders: ecological concepts at infracommunity, component and compound community levels. *American Midland Naturalist* 118: 289-300.
- Hanski, I., 1982. Dynamics of regional distribution: the core and satellite species hypothesis. *Oikos* 38: 210-221.
- Holmes, J.C. and Price, P.W., 1986. Communities of parasites. Pp. 187-213 in: Anderson, D.J. and Kikkawa, J. (eds), *Community ecology: pattern and process*. Blackwell Scientific Publications: Oxford.
- Kennedy, C.R., Laffoley, D.d'A., Bishop, G., Jones, P. and Taylor, M., 1986. Communities of parasites of freshwater fish of Jersey, Channel Islands. *Journal of Fish Biology* 29: 215-226.
- Kuc, I. and Sulgostowska, T., 1988a. Helminth fauna of *Rana ridibunda* Pallas, 1771 from Goławski Canal in Warszawa (Poland). *Acta Parasitologica Polonica* 33: 101-105.
- Kuc, I. and Sulgostowska, T., 1988b. Helminth fauna of frogs in the forest of Kampinos near Warszawa. *Acta Parasitologica Polonica* 33: 267-272.
- Lluch, J., Roca, V., Navarro, P. and Mas-Coma, S., 1987. Helminthofauna de los herpetos ibéricos: estado actual de conocimientos, consideraciones ecológicas y estimaciones corológicas. Pp. 143-161 in: Sans-Coma, V., Mas-Coma, S. and Gosalbez, J. (eds), *Mamíferos y Helmintos*. Barcelona.
- Magurran, A.E., 1988. *Ecological diversity and its measurement*. Croom Helm Limited: London.
- Margolis, L., Esch, G.W., Holmes, J.C., Kuris, A.M. and Schad, G.A., 1982. The use of ecological terms in parasitology (Report of an ad hoc committee of the American Society of Parasitologists). *Journal of Parasitology* 68: 131-133.
- Muzzall, P.M., 1990. Endoparasites of the red-backed salamander, *Plethodon c. cinereus*, from southwestern Michigan. *Journal of the Helminthological Society of Washington* 57: 165-167.
- Muzzall, P.M., 1991a. Helminth infracommunities of the newt, *Notophthalmus viridescens*, from Turkey Marsh, Michigan. *Journal of Parasitology* 77: 87-91.
- Muzzall, P.M., 1991b. Helminth infracommunities of the frogs *Rana catesbeiana* and *Rana clamitans* from Turkey Marsh, Michigan. *Journal of Parasitology* 77: 366-371.
- Prudhoe, S. and Bray, R.A., 1982. *Platyhelminth parasites of the Amphibia*. British Museum (Natural History) and Oxford University Press: Oxford.
- Sousa, W.P., 1994. Patterns and processes in communities of helminth parasites. *Trends in Ecology and Evolution* 9: 52-57.
- Stock, T.M. and Holmes, J.C., 1987. Host specificity and exchange of intestinal helminths among four species of grebes (Podicipedidae). *Canadian Journal of Zoology* 65: 669-676.
- Strüßmann, C., Riberio do Vale, M.B., Meneghini, M.H. and Magnusson, W.E., 1984. Diet and foraging mode of *Bufo marinus* and *Leptodactylus ocellatus*. *Journal of Herpetology* 18: 138-146.